# Space Weather Technical Forecast

Issued on Saturday, 02 April 2022 at 13:04 Local

**This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

## Space Weather Forecast Headline: R1/R2 and G1/G2 Likely: the chances of the former falling gradually throughout, the latter more quickly over the current UTC weekend.

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity again became Moderate in the past 24 hours, with the peak flare for the period an M2.9 observed from AR2975 at 02/0256UTC. Activity was otherwise overwhelmingly C-class, with frequent small flares that increased in magnitude into the second half of the reporting period.

There are now seven sunspot regions on the facing side of the sun, with the most active remaining AR2975 in the northwest quadrant. This group appeared to show some decay in its intermediate spots during the first half of the 24 hours, but this reversed to a degree later, finishing as an Eac/Beta-Gamma and with a new region, AR2984 emerging immediately to its east, a Bxo/Beta. This new group bisected the narrow gap between AR2975 and AR2976, with the latter showing some leading spot development but otherwise constituting a relatively placid Eho/Beta.

Elsewhere on the disc, previous rapid intermediate spot growth in both AR2981 and AR2978 slowed, with a spreading trend taking over as they showed Cri/Beta and Fhi/Beta complexity by the period's end. Completing the roster of the Earth-facing side were a pair of minor unipolar regions near the eastern limb, AR2982 and 2983.

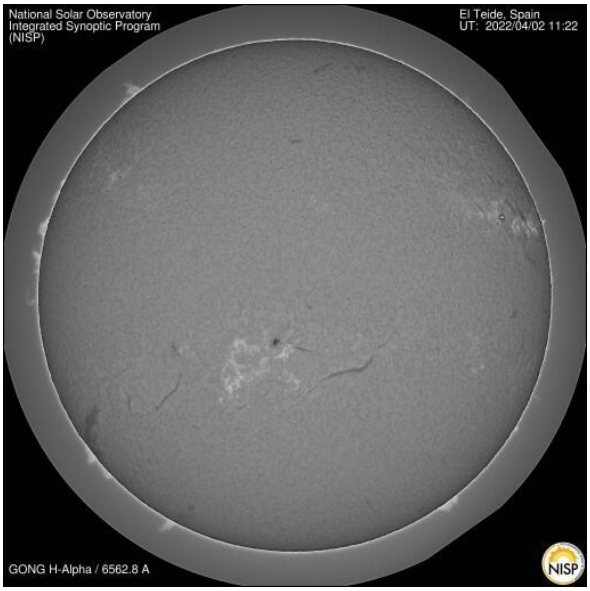


**Figure 0: El Teide H-alpha imagery showing numerous large filaments on the disc at present.**

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There remain a number of filaments on the disc, including a large one spanning the central southern hemisphere and a briefly mobile one immediately west of AR2978. At the time of writing, these all appeared to remain anchored to the disc. No Earth-directed Coronal Mass Ejections (CMEs) were observed in the last 24 hours.

**Solar Wind / Geomagnetic Activity:** The solar wind environment was characterised by the waning influence of the 28 March CME(s), possibly eventually transitioning around 02/0020UTC into a CIR-like environment, perhaps in advance of a negative polarity high speed stream. This may well be that leading CH70 or 71, and should become clearer in the ensuing hours. The phi angle was mainly negative (towards the sun), with brief positive forays with the onset of the CIR-like regime.

The solar wind speed, as measured by DSCOVR at L1, was initially Slightly Elevated around 450km/s, but showed step-wise increases at both 01/1220UTC and again at 02/0020UTC to reach 550km/s, albeit with a fair degree of instrument noise. The solar wind density was initially near normal background in single figures ppcc, but this increased into low double-figures into the UTC day of Saturday 02 April. The IMF smoothly decreased from an early peak of 13nT, with the north-south component allowed the scope to range between +8 and -9nT.

The net result of the above solar wind measures was often Unsettled, with a provisional Kp peak of '5o', Minor Storm G1, observed in the 03-06UTC interval.

**Energetic Particles / Solar Radiation:** The high energy proton flux (10MeV) measured at GOES-16 continued its gradual easing towards background levels (from a peak of S1 in the wake of the 30 March X-class flare), staying below the S1-level throughout.

The high energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO was at Normal Background levels. The observed fluence at 02/0000 UTC was 1.58e6 integrated pfu, with a very slight rising tendency since.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Further Moderate activity is Likely, primarily due to AR2975 but also the other large active regions on the disc. This risk reduces later in the period as AR2975 and AR2976 rotate over the west limb.

**Solar Wind / Geomagnetic Activity:** There is one potentially Earth-directed CME, from AR2975's X1.4 flare on 30 March. Whilst this is low confidence, with some potential for the CME to miss or only give a glancing impact, arrival is currently expected 02/1400+/-10hrs. A coronal hole fast wind arrival is also expected day 1 (Saturday 02 April). This may already be in course and could perhaps combine with any CME arrival. Any ongoing CME and fast wind effects will then gradually wane into the start of the new working week UTC.

G1/G2 Minor to Moderate storms are Likely on day one should both the fast wind and CME effects materialise. These have an ongoing potential through day two, Sunday 03 April, before a return to mainly Quiet conditions thereafter.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) is expected to soon fully revert to Background levels, but with a daily Slight Chance of rising above the S1 level, primarily from any further flare activity of AR2975, but also with any activity that develops from the other active regions on the disc. This risk reduces as AR2975 rotates over the west limb later in the period.

The high energy electron flux (greater than 2 MeV) is forecast to be at Normal Background at



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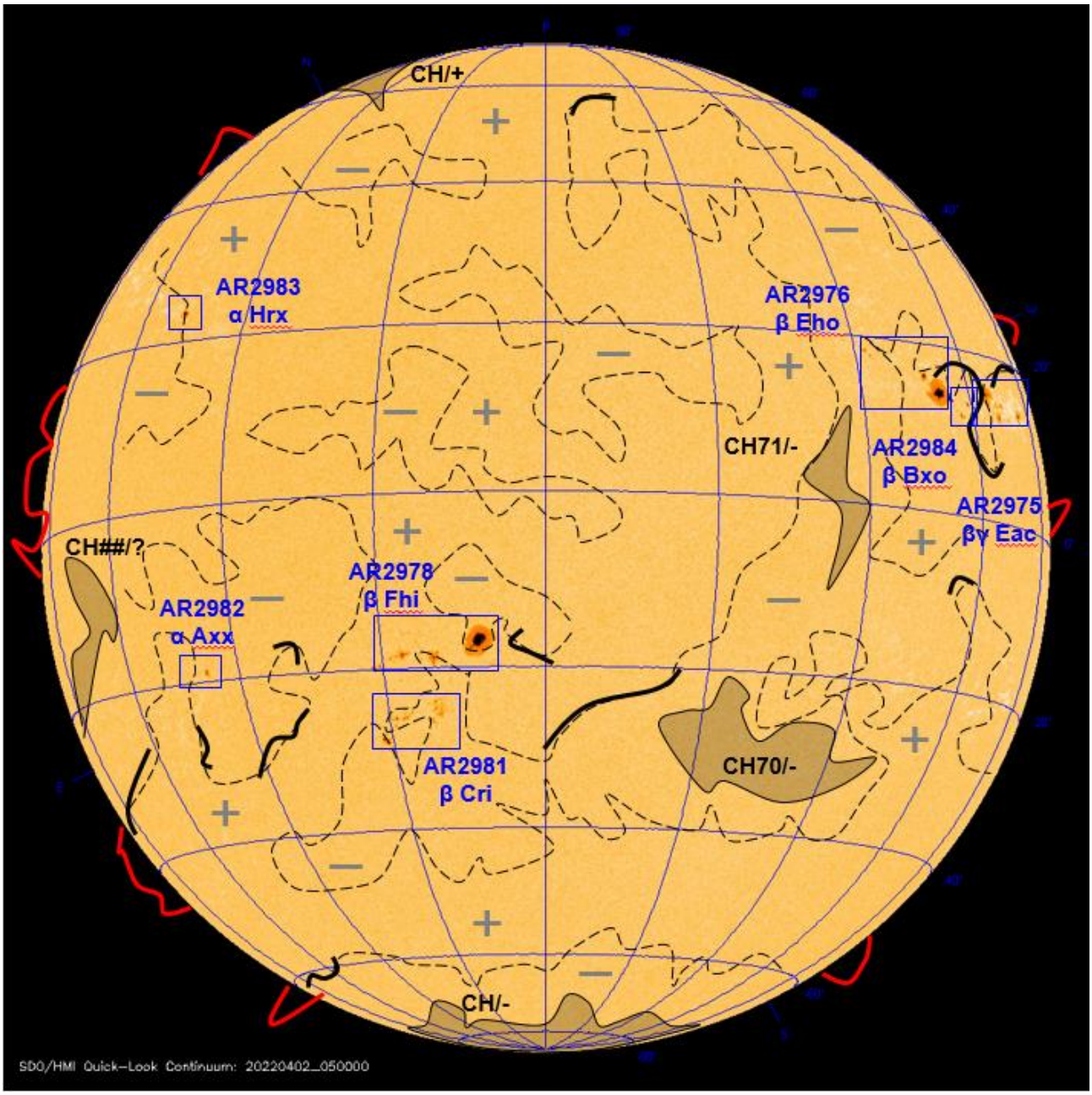
first, but likely reaching High diurnally later in the period, once the CME and any initial solar wind enhancement from the arrival of the fast wind of CH70 and 71 subside. This will bring a Chance of Active 24-hour fluence (greater than 1e8 integrated pfu) mainly day three onward (Monday 04 April).

**Figure 1. Solar Analysis Valid 02/0500UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

Earth is now thought to have departed the influence from the CME(s) from 28 March, and may now be entering a CIR-like environment ahead of coronal holes 70 and 71, with this likely to become more evident into the current UTC afternoon. Such a regime may be short-lived however, as a further potential enhancement is expected later on day one (Saturday 02 April) due to the arrival of the CME which left the Sun on 30 March - the result of the X1.4-class flare from AR2975. Whilst confidence is low regarding the extent and strength of the arrival, this is currently forecast to arrive at 02/1400 UTC +/-10hrs. No other CMEs have been assessed as being Earth-directed.

As for the subsequent forecast, this depends on the cause of the current CIR-like enhancement, which may be related to CH70 or 71, else these are still due and may further kick geomagnetic activity this weekend. Complicating matters is the fact that there was little sign of any fast wind on STEREO A, and neither of the possible coronal holes align with observed fast wind conditions on the previous rotation, leading to significant uncertainty.

All considered, the likely trend in geomagnetic activity is upward in the immediate term, but with an eventual downward tendency in the four days, becoming Quiet into the new working week. Prior to this, G1/G2 is Likely from the combined effects of the impending CME and any CH70/71 fast wind over the UTC weekend.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | Yes | 70 | 40 | 5 | 1 |
| Strong | G3 | No | 5 | 5 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 30/1738 | Partial | X1.4 flare | AR2975 N05W040 | 700km/s | 02/1400UTC +/-10h | Low confidence, possible glancing impact |

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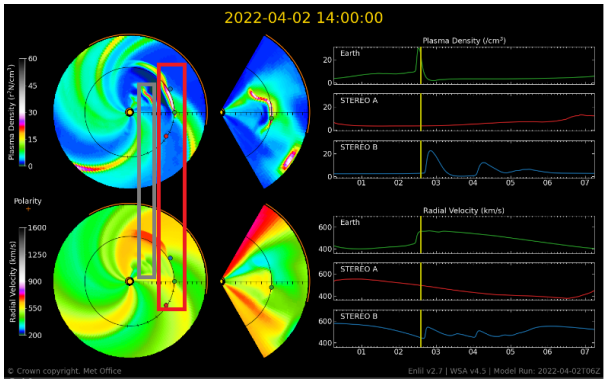
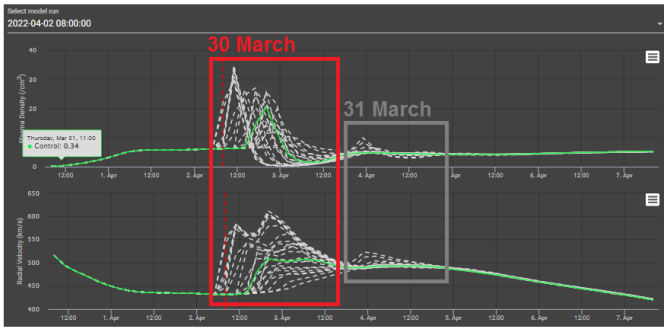
**Figure 2: L1 solar wind measures over the past 72 hours, showing the onset and span of the 28 March CME(s), and their eventual evolution into a possible CIR into CH-like environment, with the speed and density increasing after 02/0020UTC in a possible CIR.**

**Figure 3: MOSWOC Enlil model and ensemble, showing upcoming X1.4 CME (boxed red) from 30 March and close pass of 31 March M9 CME (boxed grey). The former features in the forecast as a possible glance during day one, the latter is discounted.**

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## Radio Blackouts - X-Ray Flares:

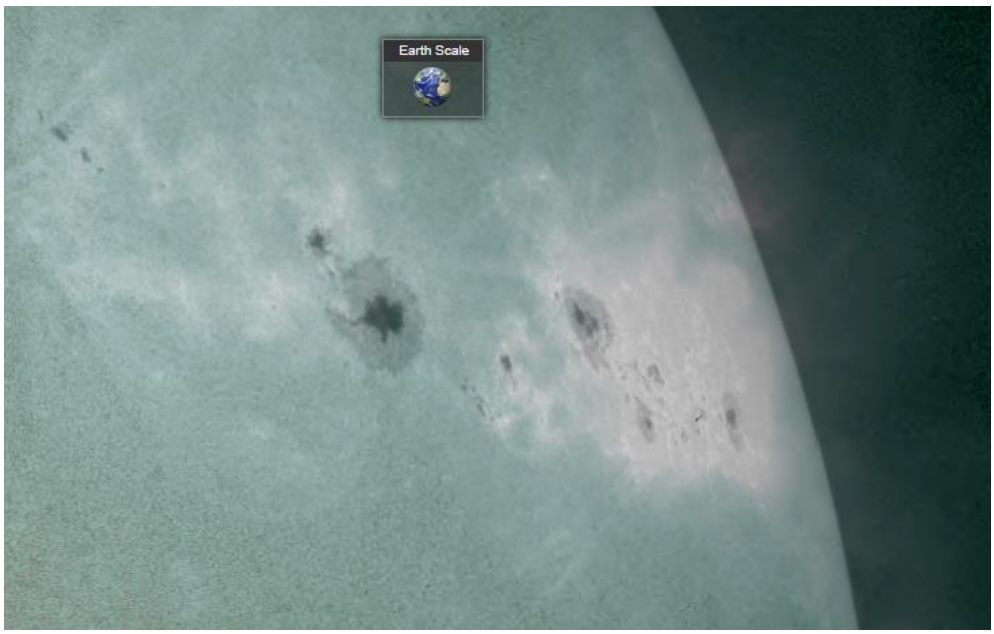
Solar activity rose to Moderate in the past 24 hours, with sunspot region AR2975 again delivering in the form of an M2.9 X-ray flare, peaking at 02/0256UTC.

Solar activity has been dominated in the past week by the large and active AR2975, which now occupies the sun's northwest, along with similarly large but less active AR2976, and now a newly-developed region separating them, AR2984. The development of AR2984 itself may still hint at a latent feature driving activity in this part of the sun, in a similar manner to that which developed for a period in the UTC day of Friday under the southeastern quadrant sunspots - this now appears to have eased.

The daily risks of significant flares are - on paper - partitioned fairly equally between the largest of the seven groups on the disc, namely AR2975, 2976, 2978 and 2981, although in reality AR2975 is dominant. This factors into the above probability forecast, with the crossing of AR2975 onto the far side giving a significant reduction in risk, a trend that should continue as AR2976 follows suit.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 70 | 70 | 60 | 50 |
| Very Active | R3 to R5 X Class | No | 15 | 10 | 5 | 5 |

**Figure 4: Composite image overlaying HMIIF and AIA 094 imagery from the time of the M2.9 flare at 02/0256UTC. Left to right are sunspot regions AR2976, 2984 and 2975. Image overlay courtesy of Helioviewer.org.**

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## Solar Radiation Storms - (High Energy Protons):

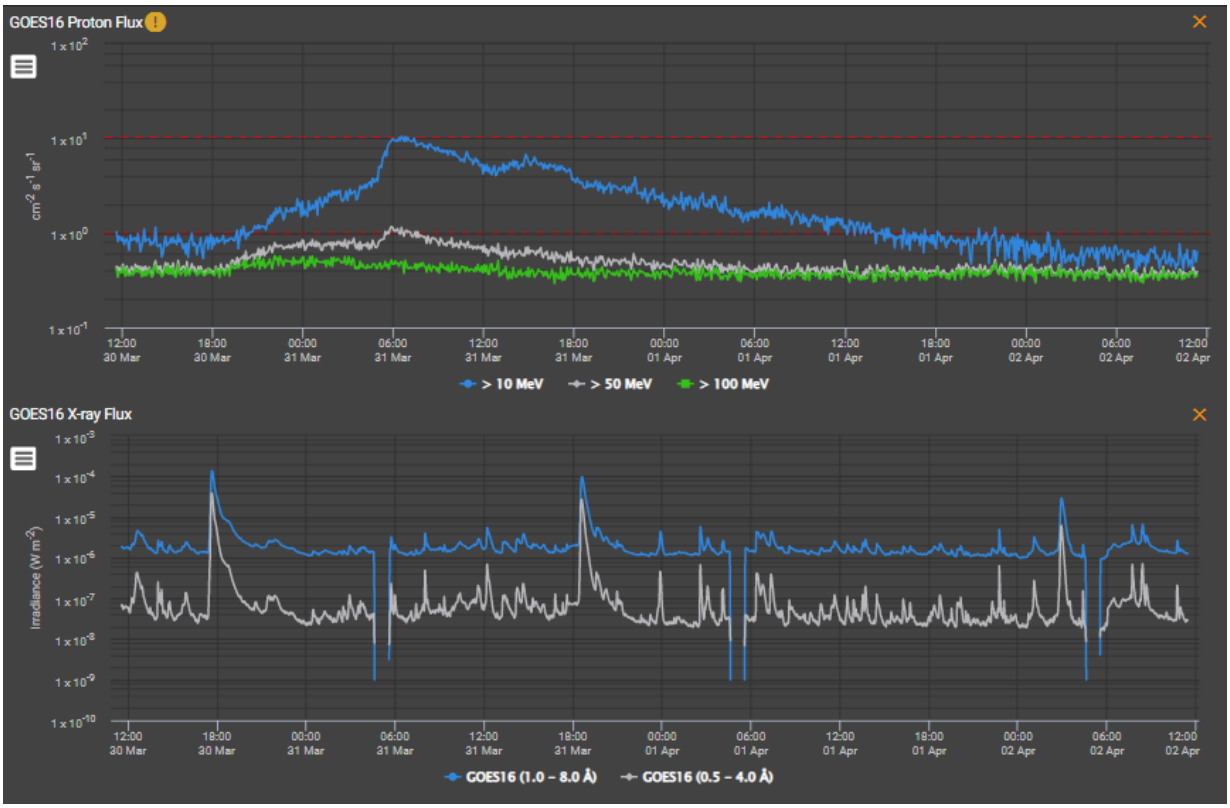
The high energy proton flux (10MeV) measured at GOES-16 has been falling back to background during the last 24 hours, and should fully settle within the current UTC day.

AR2975, approaching the northwest limb, has produced proton-rich flares and continues to have the potential for M- and perhaps low X-class flares. Furthermore, there are a number of other potential flare sources on the disc, including AR2976 closely following AR2975, and also AR2978 and AR2981 in the southeast.

Overall, this maintains a daily Slight Chance of the proton flux rising to the S1 level, although this should very gradually reduce with time, as AR2975 in particular rotates away from 90 West, with the other regions yet to prove their mettle in terms of generating S-scale events.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | ≥ S1 | No | 15 | 15 | 10 | 5 |
| Very Active | ≥ S3 * | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 5: Top: GOES 16 High energy proton flux spectrum, showing delayed initial rise of 10MeV to S1 in wake of the X1.4 flare (shown bottom image), followed by a gradual decline.**

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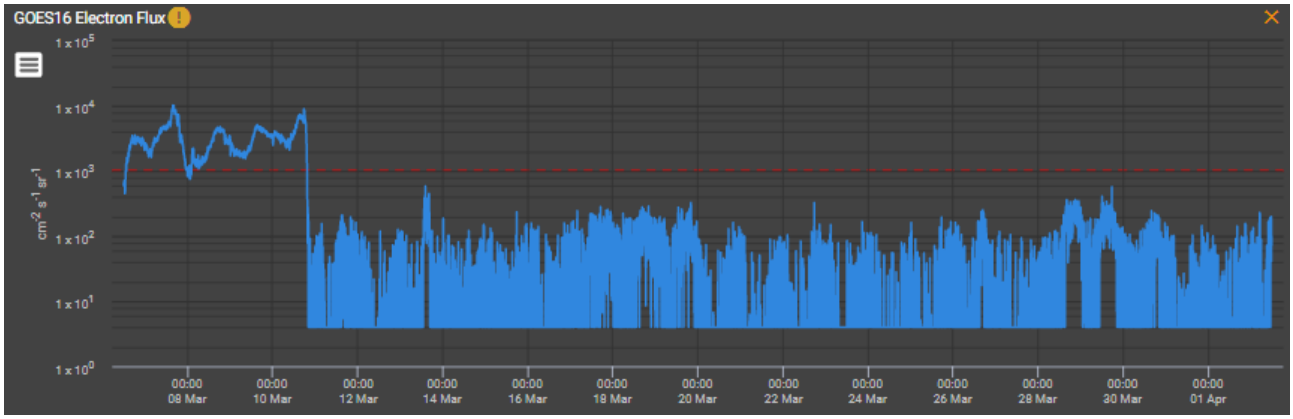
## High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) flux, as observed by GOES-16 at GEO is expected to be largely background levels day one, (Saturday 02 April) with the potential for geomagnetic enhancement from arriving fast winds of CH70 and CH71, along with the expected arrival of the CME from the X-class flare that occurred on 30 March. Flux levels then have the potential to rise later in the period as the near-Earth solar wind environment eases, most likely into the new working week UTC. This will bring a chance of diurnal spells of High flux, perhaps becoming persistently High by the end of the period.

The associated 24-hour fluence will remain below the Active (1e8 integrated pfu) level at first, but has an increasing chance of rising above thereafter. REFM gives a good guide to the next 24 hours in the absence of any CME or fast wind arrival. However, its value will be much-reduced beyond this period given any CME interjection.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 10 | 30 | 30 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 5 | 5 |

**Figure 6: GOES 16 high energy electon flux over a whole 27-day rotation, showing that based on persistence, the only realistic chance of exceeding high flux is in the upcoming few days, although this is low confidence.**

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